

# **Ultra High Bypass Ratio Engine Research for Reducing Noise, Emissions, and Fuel Consumption**

## **Presentation Abstract**

A pictorial history of NASA development of advanced engine technologies for reducing environmental emissions and increasing performance from the 1970s to 2000s is presented. The goals of the Subsonic Fixed Wing Program portion of the NASA Fundamental Aeronautics Program are discussed, along with the areas of investigation currently being pursued by the Ultra High Bypass Partnership Element of the Subsonic Fixed Wing Program.



# **Subsonic Fixed Wing Project**

*.... technology for dramatically improving noise, emissions, & performance*

## **Ultra High Bypass Ratio Engine Research for Reducing Noise, Emissions, and Fuel Consumption**

***Chris Hughes, NASA SFW Ultra High Bypass Partnership Manager***

***Jeff Schweitzer, Pratt & Whitney Advanced Commercial Engine  
Programs Manager***

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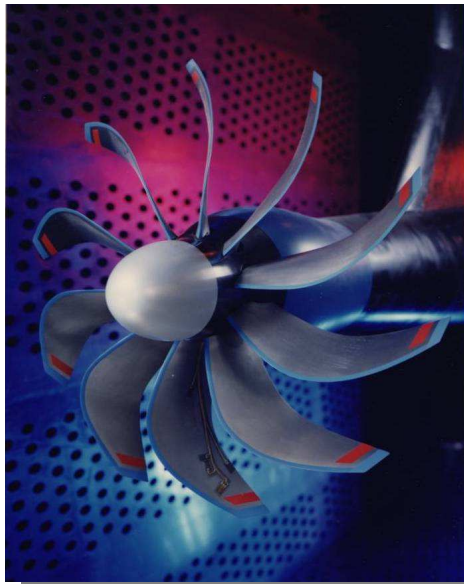
October 30 – November 1, 2007



# Strong History of Technology Development

## ➤ 1970s

- Single Rotation Propfans
  - Significant improvement in fuel burn



*SR-5 Fan in  
Glenn 8'x6' Wind Tunnel*

*Large Advanced Propeller  
Full Scale Static Test*



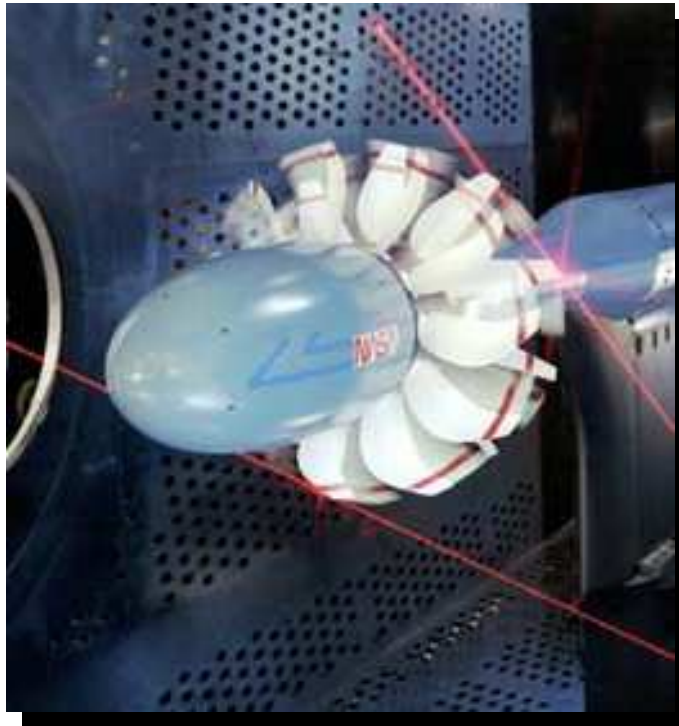
*Propeller Test Assessment Aircraft Demo*



# Strong History of Technology Development

## ➤ 1980s

- Counter Rotation Propfans
  - Reduce installation effects, improve efficiency



*Counter Rotation Propeller in  
Glenn 8'x6' Wind Tunnel*

*GE Unducted Fan / 727 Flight Demo*





# Strong History of Technology Development

## ➤ 1990s

- Ultra High Bypass Engine Cycle concept
  - Reduce noise and fuel burn



*17" Advanced Ducted Propulsor  
in Glenn 8'x6' Wind Tunnel*

*22" Advanced Ducted Propulsor  
in Glenn 9'x15' Wind Tunnel*







# Strong History of Technology Development

## ➤ 1990s

- Advanced noise reduction technologies for turbofans
  - Increased rotor-stator spacing
  - Reduced fan tip speed
  - Swept / Leaned stator vanes



*Swept stators*



*Leaned stators*



*Swept & leaned stators*

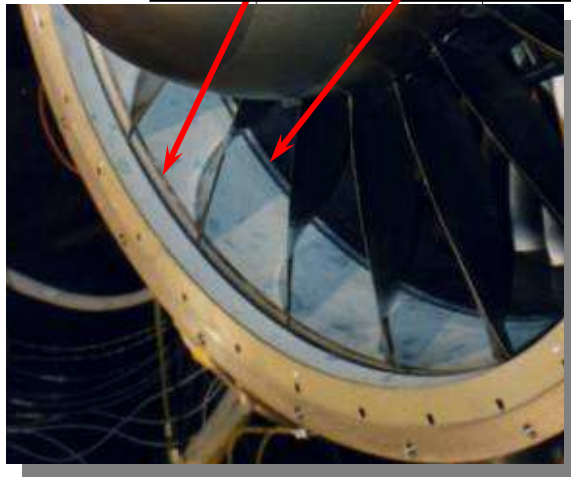
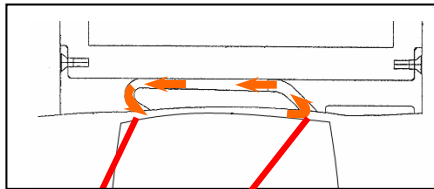


# Strong History of Technology Development

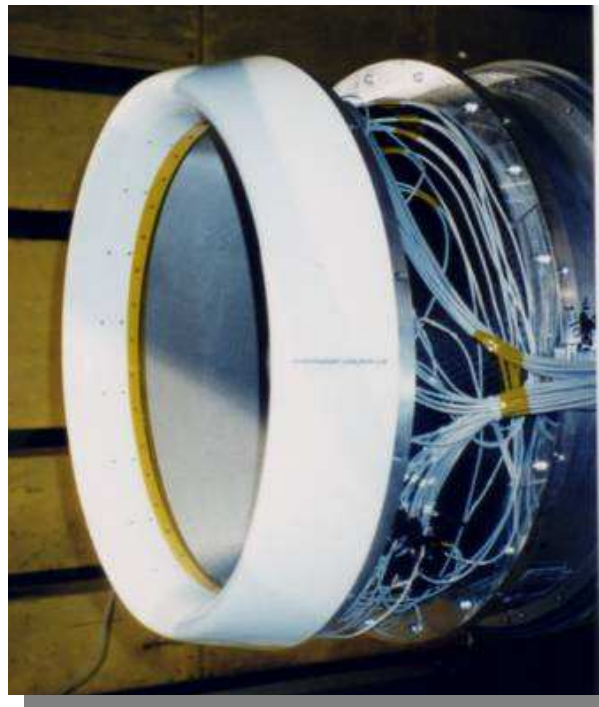
## ➤ 1990s

- Advanced noise reduction technologies for turbofans

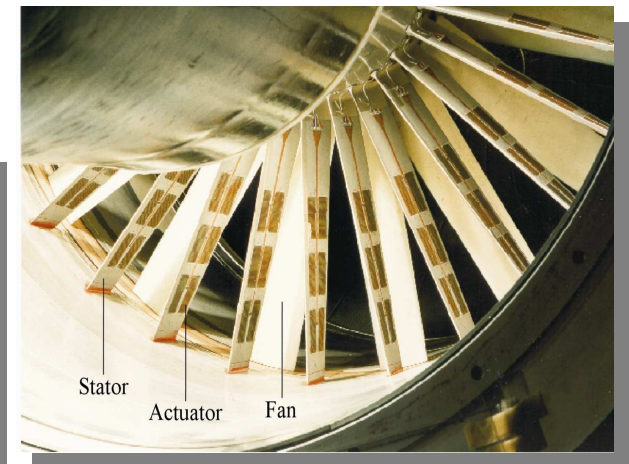
- Fan blade tip flow management



- Active and passive liners



- Active noise control

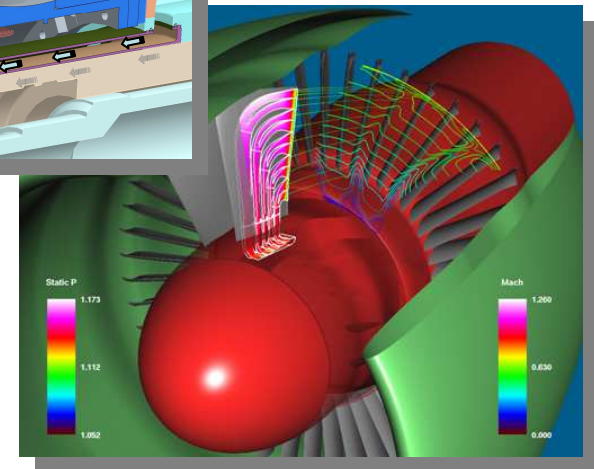
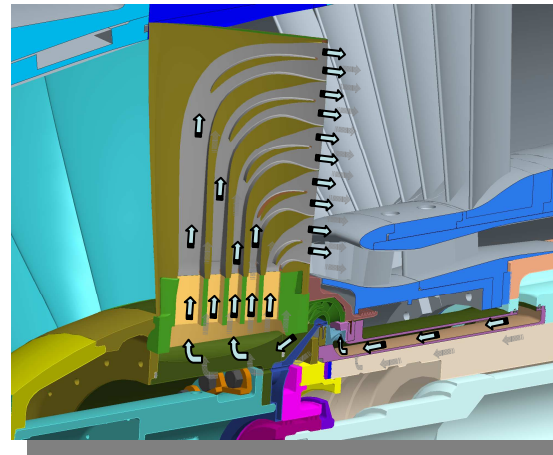




# Strong History of Technology Development

## ➤ 2000s

- Advanced noise reduction technologies for turbofans
  - Highly swept fan blade
  - Fan trailing edge blowing

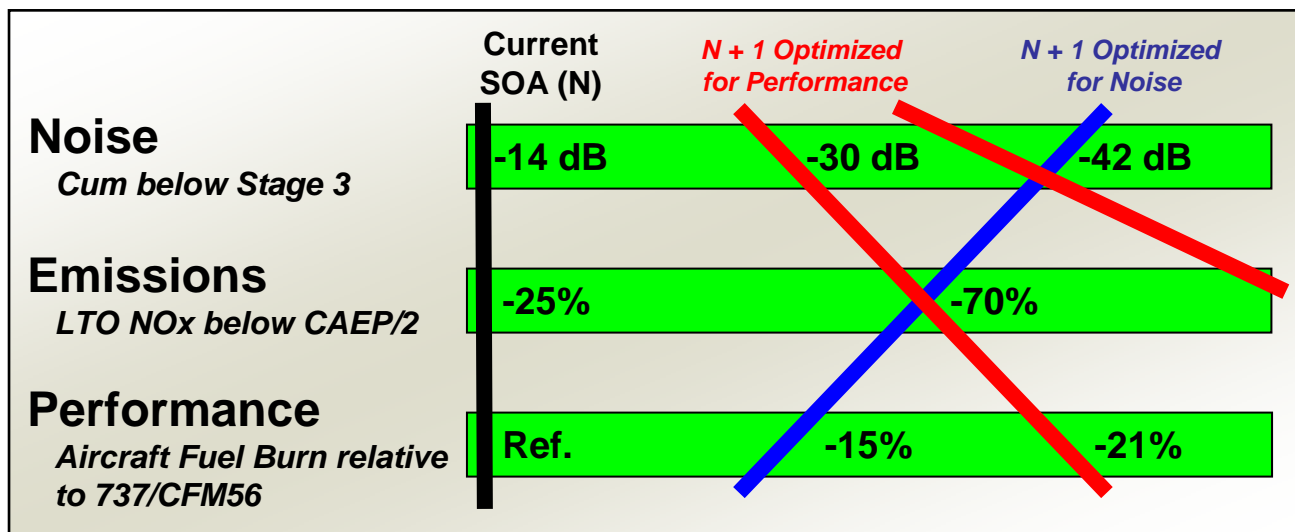






# Today's Challenges

- Refining and improving on previous noise reduction and performance improvement technologies and demonstrating their combined effectiveness is necessary to meet the aggressive SFW goals for “N + 1” aircraft
  - Noise: -42 cum below Stage 3
  - Emissions: -70% LTO NOx below CAEP/2
  - Performance: -15% Fuel Burn below B737/CFM56
- However, limited goals trading is possible

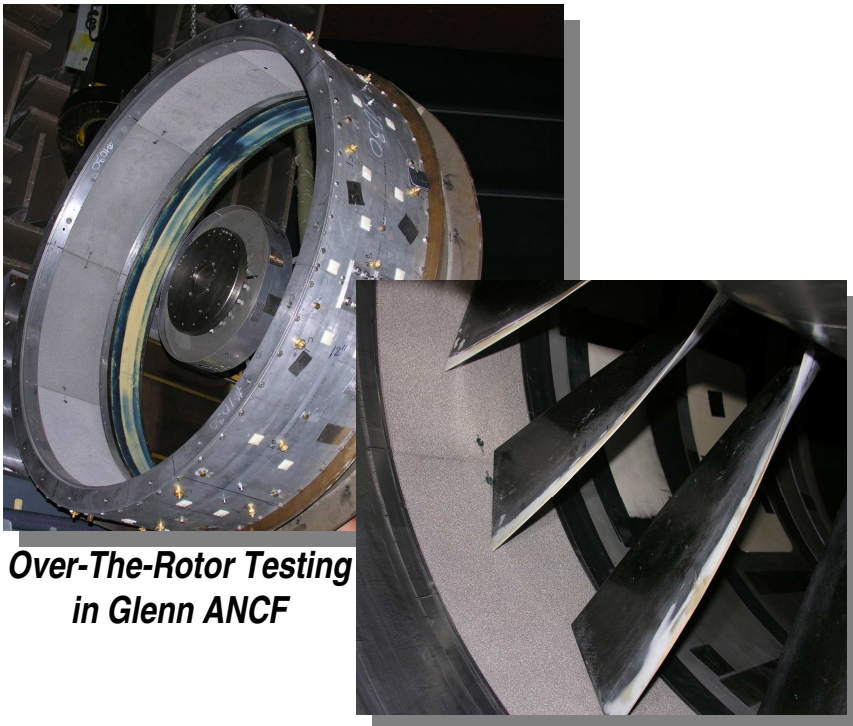




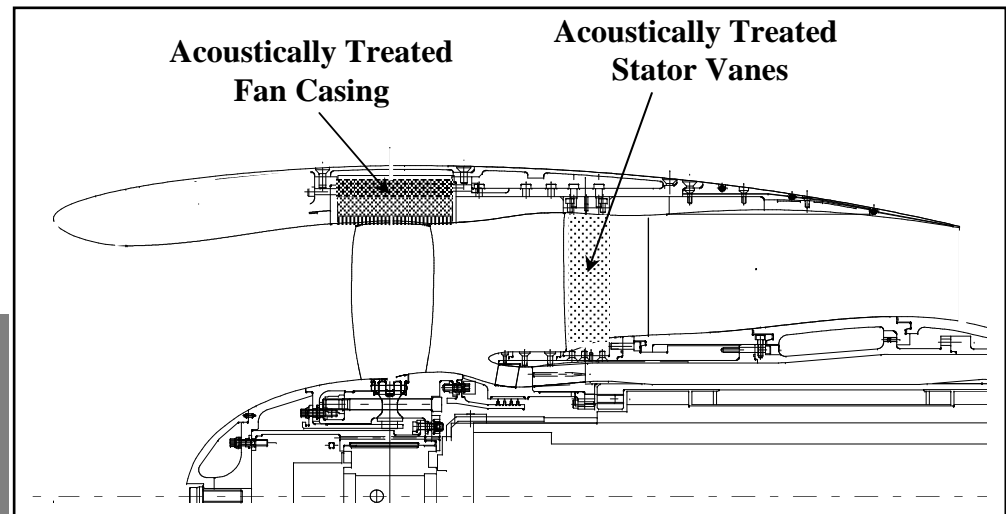
# Current Areas of Investigation

## ➤ Noise Reduction

- Acoustically treated fan casing – “Over-The-Rotor” metal foam insert
- Acoustically treated stator vanes – “Soft Stators”



*Over-The-Rotor Testing  
in Glenn ANCF*



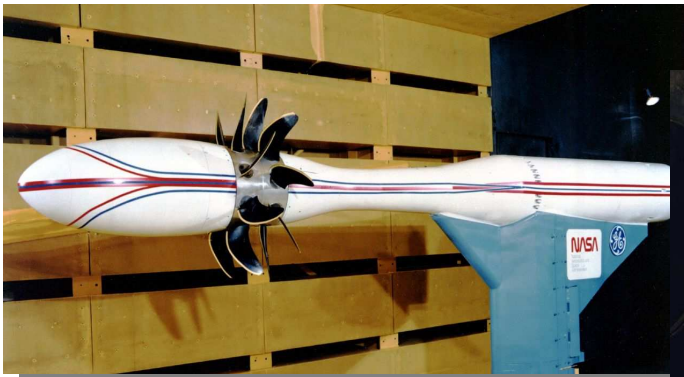
*OTR and Soft Vanes design in  
22" Advanced Ducted Propulsor model*



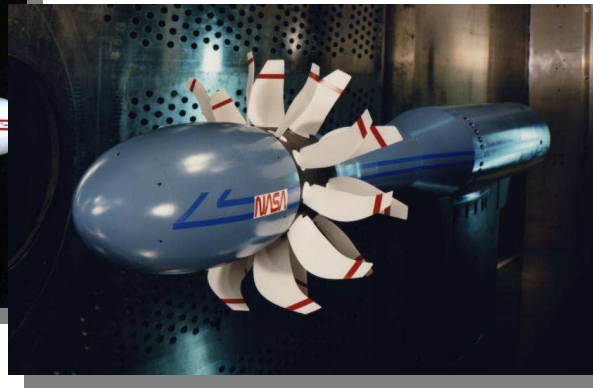
# Current Areas of Investigation

## ➤ Performance

- Nacelle/Airframe Integration Aerodynamics
- Counter Rotation fans (Bypass Ratio  $>30$ )
  - NASA Glenn rig being refurbished now



*Approach/Takeoff*



*Climb/Cruise*



*Aerodynamics Test  
in Ames 11' Wind Tunnel*

## ➤ Emissions

- Alternative fuels



## SFW UHB Partnership Element

### ➤ Objective

- Demonstrate and validate Ultra High Bypass engine cycle noise, emissions and performance improvement technologies in full scale applications
- Through collaboration with Industry, the SFW Program goals can be achieved